

SMS OPERATIONS-EQUIPMENT PREPARATION

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16. Abstract  Various equipments connected with planned SMS telemetry operations in cooperative CNES-NASA venture are to be exercised and tested for interoperability. Configuration of test and operational set up at the Brazzaville station described. Report of minor difficulties encountered has been transmitted to NASA.			
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SMS OPERATIONS - EQUIPMENT PREPARATION

1. REVIEW OF THE SMS MISSION

/1\*

1.1. NASA requested the cooperation of CNES within the scope of the "SMS Satellite Launch" mission.

This participation essentially boils down to the following actions:

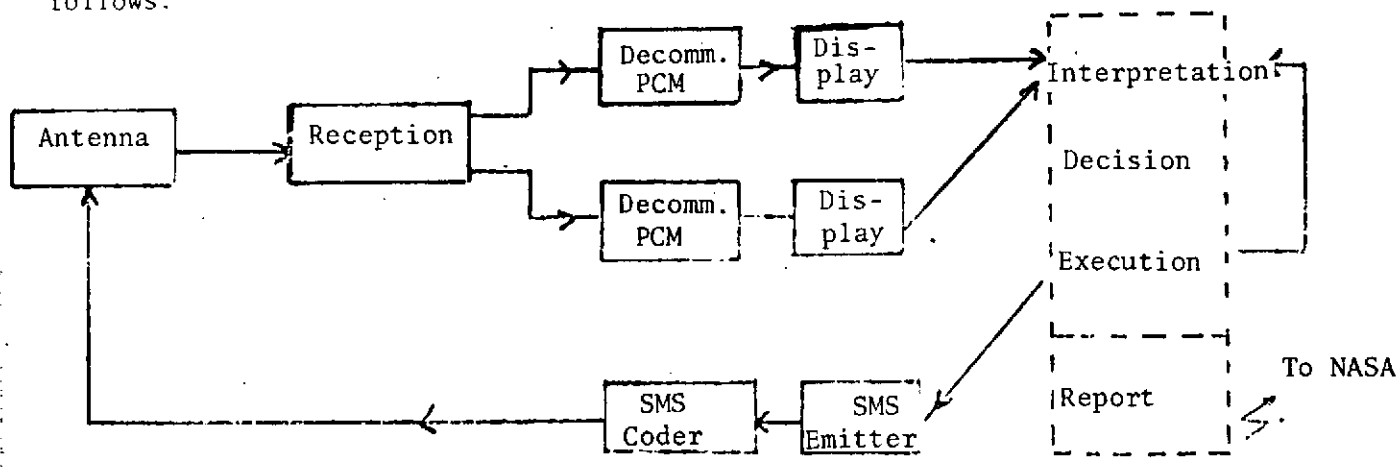
From the Brazzaville station:

- Reception of satellite transmitted telemetry.
- Decommuration of this telemetry for the purpose of ascertaining:
  - the third-stage THOR DELTA - Satellite separation;
  - the placement in operation and good functioning of the satellite's automatic nutation control.

- For the purpose of this decommuration, the contingent sending of command guidance orders intended to counter a failure of this automatic nutation control system.

- The transmission by voice and telex of all useful data to the Operations Control Center located at Greenbelt (GSFC).

1.2. The flow chart of the equipments utilized for this operation is as follows:



\*Numbers in the margin indicate pagination in the foreign text.

It has been conceded that all equipments downstream from reception, i.e., /2  
the decommutation and command guidance functions were defined as "specific  
SMS" and produced, in part, by means of material supplied by NASA.

## 2. THE TESTING GOAL

The tests carried out at the Toulouse station have as their goal:

- the reception of the material placed at the disposal of CNES by NASA and the supervision of its good operation;
- the design, production and development of decommutation and command guidance lines;
- the accomplishment of a complete simulation of the operation starting from magnetic tapes likewise supplied by NASA.

## 3. TESTING TIMETABLE

- 25 September  
Arrival of NASA material at Toulouse.
- From 25 to 29 September  
Unpacking, inventory, mechanical and electrical integration of these equipments.
- From 1 to 3 October (in collaboration with Mr. J. C. Anne)  
Energizing NASA equipments, trouble shooting, supervision of good operation. Analysis of interface problems between CNES and NASA.
- From 3 to 31 October (irregularly): /3
  - At Bretigny (J. C. Anne): Design and beginning of construction of a model incorporating pre- and post-discrimination filter.
  - At Toulouse: Solution of the interface problem. Setting up many interconnecting cables between CNES and NASA equipments.
- From 5 to 9 November (in collaboration with J. C. Anne)  
Total supervision of complete transmission and decommutation networks with the exception of the prediscriminating filter. Simulation trial beginning from magnetic tapes supplied by NASA. Complemental measurements with coder, PM modulator and transmitter.

- 12 November

Performance of a simulation beginning from a circuit set up at the station.

- 15 November

Shipment to Brazzaville (BZV) via MAT of the largest part of the NASA and CNES materials required for carrying out the operation.

- 22 November

Shipment to BZV, via MAT, of one last set of spare parts which had been held up in customs.

- From 22 November to date

Continuance at Bretigny by J. C. Anne of the final design of the model containing the pre- and post-discrimination filters. Planned final completion date: end of January 1974 (subject to problems of component supply).

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#### 4. TESTING PERFORMANCE

/5

##### 4.1. Rehabilitating NASA Equipments

##### 4.1.1. Summary of materials supplied by NASA

The set of specific SMS material supplied by NASA is essentially composed of:

- 1 200 w Collins transmitter
- 1 50  $\Omega$  charging set
- 1 PM modulator
- 1 specific SMS coder made up by two separate racks
- 1 Hewlett-Packard 5050 B printer
- 1 drawer-type power unit
- 1 set of interconnecting cables
- 1 set of spare parts
- 1 set of technical documentation

This material was given a quantitative check upon arrival. In this way, it was found that the set of spare parts for the coder was incomplete. More specifically, a certain number of types of spare cards were missing. The latter were requested from NASA who subsequently forwarded them.

#### 4.1.2. Energizing and Supervision of Good Operation

##### 4.1.2.1. Continuous Power

The drawer-type continuous power unit (+ 5 and + 18 V) can only be supplied with 110 V. It was therefore necessary to provide it with power from the Marechaux-Dubost autotransformer available at the station. The output voltages were vacuum-measured and with load. Nothing to note.

##### 4.1.2.2. Command Guidance Coder

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No energizing problem found but there were some functional irregularities which were repaired sequentially.

- Inhibition of the coder. Here the coder is normally in "distant" operation. In order to have it operate in "local", it is necessary to lead in the equipment at the level of its "Master Control" plug. We finally found this lead in the set of spare parts.

- Systematic appearance of a warning signal with "ground verification error". Use of gain control of modulator amplifier (R36 on card 322 of the CAGE).

- No "transmitter lock-on" signal outputting from the coder. Changing the card concerned (SP 56 at position 316 of the CAGE).

- Absence of 640 Hz distribution. Unsoldered wire.

- Erratic readout of a bit in the data of telemetry down-link (Spacecraft Verify). Unsoldered wire.

The investigation of these breakdowns was carried out without any major problems and taught us how better to manipulate the logic diagrams of the operating instructions which can be considered as models of this type.

Let us, nevertheless, note some differences between diagrams and reality. We were indeed surprised to discover a few resistors installed at the end of a lead and enclosed in a retractable sheath making their identification especially difficult.

#### 4.1.2.3. PM Modulator and Collins Transmitter

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The rack containing the PM modulator and Collins transmitter was ready for a 220 V power supply. We supplied it with a switch installed downstream from the transmitter blower in order to avoid any start of operation from the power switchboard of the station.

No difficulty appeared with the PM modulator. However, the Collins transmitter gave us a few adjustment problems. It finally turned out that one of the output tetrodes (7034/4×105A) was at the end of its service life. This tetrode had not been changed at Toulouse. The standard exchange will be made at Brazzaville (BZV).

#### 4.1.2.4. The HP 5050B Printer

The power supply for this printer was shifted to 220 V. Some mechanical adjustments were made to improve printout quality.

#### 4.1.3. Measurements of Performance

##### 4.1.3.1. Coder

All of the measurements provided for in the maintenance chapter of the coder's operating instructions were carried out and showed that the adjustments of the coder were satisfactory. In particular, the clock lag was measured, referring to the lag between the instant at which the bit conversion occurs and the instant when the signal envelope passes to its mean value.

##### 4.1.3.2. PM Modulator

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The modulation depth was confirmed. The tuning of the transmission frequency was done.

The VHF frequency transmitted was demodulated by using the 150/138 MHz converter and the IRIS receiving link. It was made clear in this way that there was no variation in clock lag introduced by the modulation.

##### 4.1.3.3. Collins Transmitter

The rated power (200 watts) was reached. We did not carry out a measurement of distortion rate.

#### 4.1.4. Total Checkout of Transmitting Link

The total checkout of good operation can be done in two ways:

##### 4.1.4.1. Checkout with "Internal"

For this, set the coder on "Internal Verify". This checkout is then accomplished automatically at the beginning of each transmission. Any anomaly is detected by the "Ground Verify Error" circuit.

##### 4.1.4.2. Checkout with "External"

This checkout requires placing in operation the 150 MHz receiving link available at the station. The checkout procedure is then as follows:

- Put the coder on "External Verify";
- Transmitter on load;
- Incoming signal from the amplifier of the transmitter connected to the 150/138 MHz converter of the station;
- Ensure communications with an IRIS receiver whose coherent PM output is connected to the "Verify VHF" input of the coder;
- At first, transmit a pure carrier in order to allow lock-on of the IRIS phase lock;
- Then, transmit any variety of command guidance order.

Any anomaly will likewise be detected by the "Ground Verify Error" circuit.

#### 4.2. Design and Production of Specific Equipments

##### 4.2.1. Prediscriminating Filtering

(Editor: J. C. Anne)

##### 4.2.1.1. Goal

The preliminary tests carried out at PTA concluded that interference of the IRIG 12 channel was being caused by the PCM.

It was therefore planned to design a narrow-band prediscriminating filter centered on the mean frequency of the IRIG 12 signal.

Research showed that a band pass on the order of  $\pm 50$  Hz was suitable for the sought after goal.

#### 4.2.1.2. Principle

The main problem involves the drift of the embarked VCO. The result of this is a requirement for automatic tuning of the central frequency of the filter.

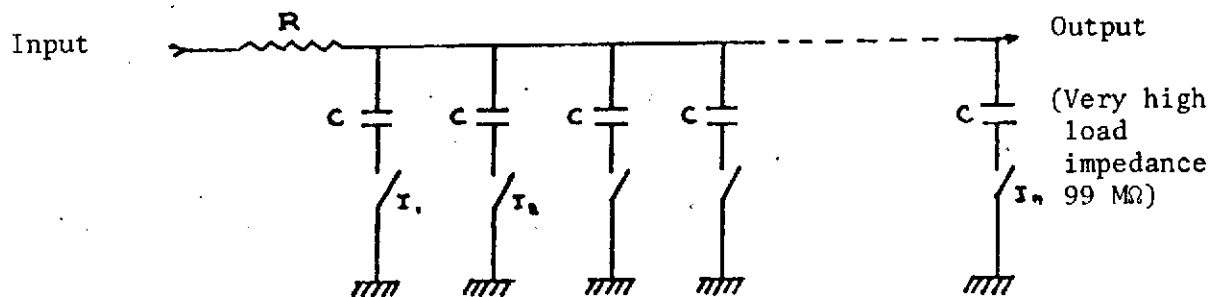
On the other hand, a conventional design with active filter base would have required high-precision components hardly compatible with automatic tuning.

A solution based on frequency changes required image frequency rejecting filters with high-performance operation.

A new solution was planned: a commutated filter.

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A filter of this type is shown schematically below:



The  $I_j$  switches are closed successively. The operation is similar to the one for a synchronous demodulation.

The switches were produced by FET.

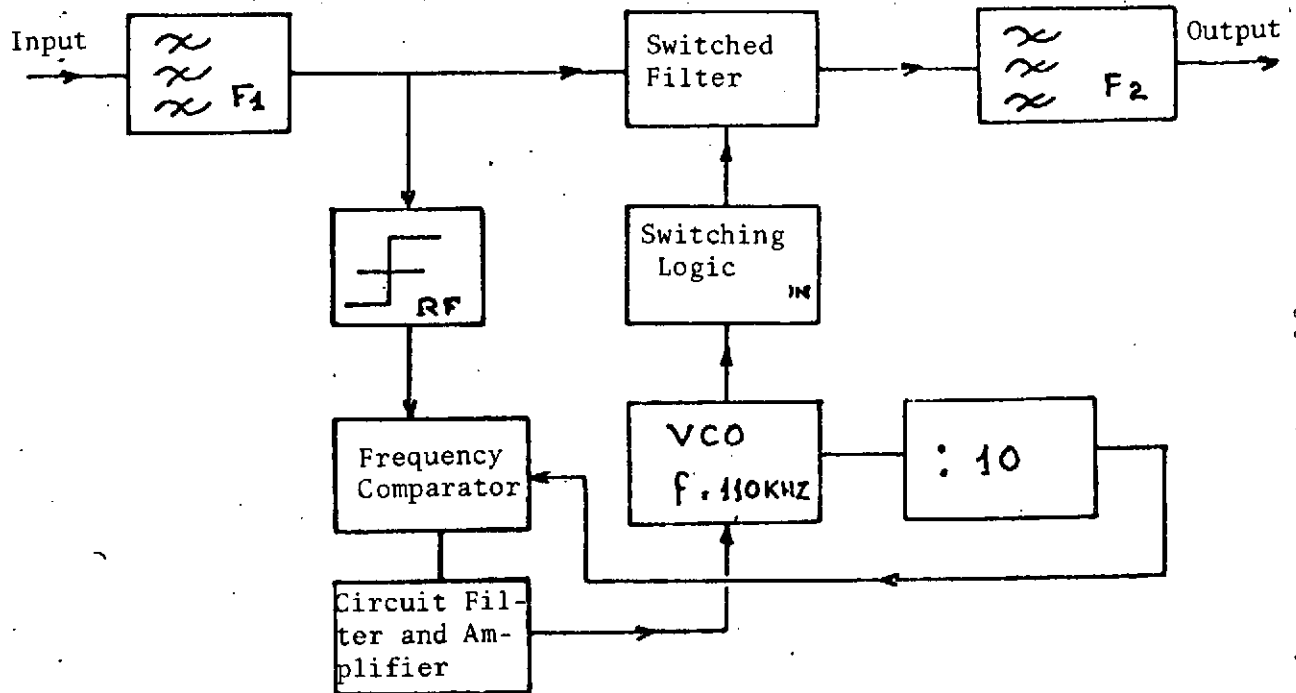
The band pass is determined by the switching frequency.

This filter lends itself especially well to an application with a variable Q, constant band pass, tunable central frequency.

The rejections are low but substantial.

A coarse reset is necessary by an active low-performance active band pass filter.

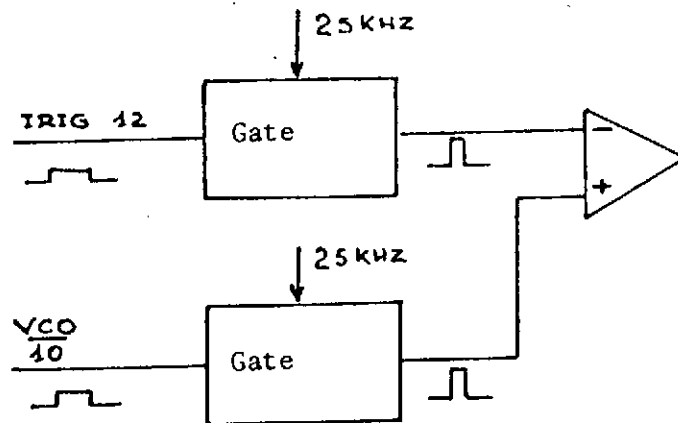
A block diagram follows with commentary:



The F1 filter is intended to sufficiently attenuate the PCM to allow proper operation of the RF limiter (reshaping) which transforms the sinusoidal IRIG 12 signal into a 0.5 V TTL square wave.

The frequency comparator supplies an error voltage proportional to the frequency deviation between  $F_{VCO}/10$  and IRIG 12 and, in order to adhere to the specifications in stability and in temperature, the frequency comparator includes a circuit which delivers calibrated pulses (25 kHz clock) with each positive alternation of incident frequencies (one pulse per alternation).

A high-performance differential amplifier is used to minimize temperature drifts. /13



#### 4.2.1.4. Testing

The laboratory apparatus is presently being produced. The different parts have been tested individually. However, total operation has not yet been tested.

#### 4.2.1.5. Comment

The PTA results have not been recovered insofar as concerns the degradation of the IRIG 12 owing to the PCM and there is still a doubt as to the operational requirement for this filter.

#### 4.2.1.6. Conclusion

While waiting for more representative operational testing to be carried out at BZV starting from future simulation bands, the production of the pre-discriminating filter is continued. This testing should validate or invalidate the operational requirement for this filter.

### 4.2.2. Post-Discriminating Filtering

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(Editor: J. C. Anne)

#### 4.2.2.1. Goal

Two reasons suggest the requirement for filtering the signal outputting from the discriminator.

a) The index of modulation of the IRIG 12 channel provides a signal-to-noise ratio preventing exploitation of the demodulated signal, even with a strong field.

The IRIG 12 channel has a band pass on the order of 160 Hz whereas the nutation signal has a frequency on the order of 1 Hertz.

The existence of pulses widening the spectrum of the signal should likewise be taken into account.

It is therefore possible to reduce the band pass by using a low-pass filter. For validation purposes by means of an experimental sequence using a signal nutation plus pulses, the cut-off frequency was selected at 10 Hz.

b) The FM telemetry has the special feature of "passing the continuous" such as, among others, the drifts of the VCO used for the modulation. These drifts risk impeding exploitation and NASA has recommended introducing a high-pass filter. The cut-off frequency has been given to 0.1 Hz.

Without fail, a low-pass filter is in the circuit of the tunable discriminator of the stations.

There still remained, at the time of the technical mission of July 1973 at Washington, an uncertainty as to the use of a redundant IRIG 12 channel supplied by NASA and as to whether low-pass filtering should be carried out. As a result, a specific filter was designed.

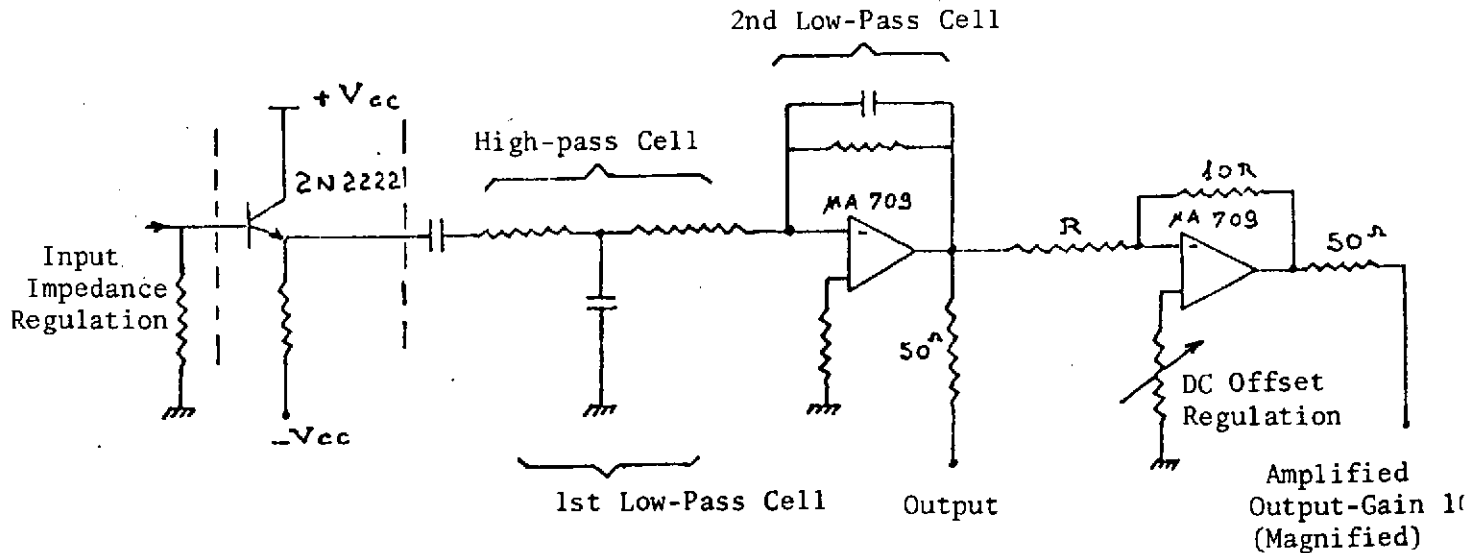
/15

#### 4.2.2.2. Principle

A response of the type  $\frac{1}{(1+\zeta)^2}$  or 12 dB/octave has been arbitrarily selected for the low-pass part. As for the high-pass part, a 6 dB/octave response has been selected.

By definition, if this can be said, the input impedance of the filter is very high and the output impedance is on the order of 50  $\Omega$ . The filter is an active filter.

#### 4.2.2.3. Design



The power supplies are delivered by the general power supply of the NASA coder ( $\pm 15$  V) and are bypassed on the card.

Two filters were produced (one being in excess). Each one is set on a printed card.

The system is installed in a drawer-type unit.

The commutation of the filter is ensured on the panel.

/16

#### 4.2.2.4. Testing

The band pass in the laboratory is 0.1 Hz, 11 Hz. The drop is 12 dB/octave.

The filter validated its effectiveness in simulation tests. What remains unknown is the behavior in the presence of pulses which could not be simulated.

#### 4.2.2.5. Conclusions

One test remains to be done using a simulation band when it becomes available.

The goal of this test will be to verify whether the pulses remain "readable" in spite of the reduced band pass. In the contrary case, an attempt will be made to find a readability compromise for the pulses, signal-to-noise ratio on the nutation wave shape.

#### 4.2.3. Design of an "SMS Exploitation" Rack

The coder, printer and power supply drawer having been supplied by NASA in the form of racks, it quickly turned out to be advantageous to incorporate these equipments in one rack.

This incorporation was carried out from an operational perspective: creation of one position for exploiting data and carrying out command guidance. It did, indeed, appear to be advantageous to group together at the same spot:

- the PCM decommutation function;
- the PAM decommutation function;
- the command guidance execution function.

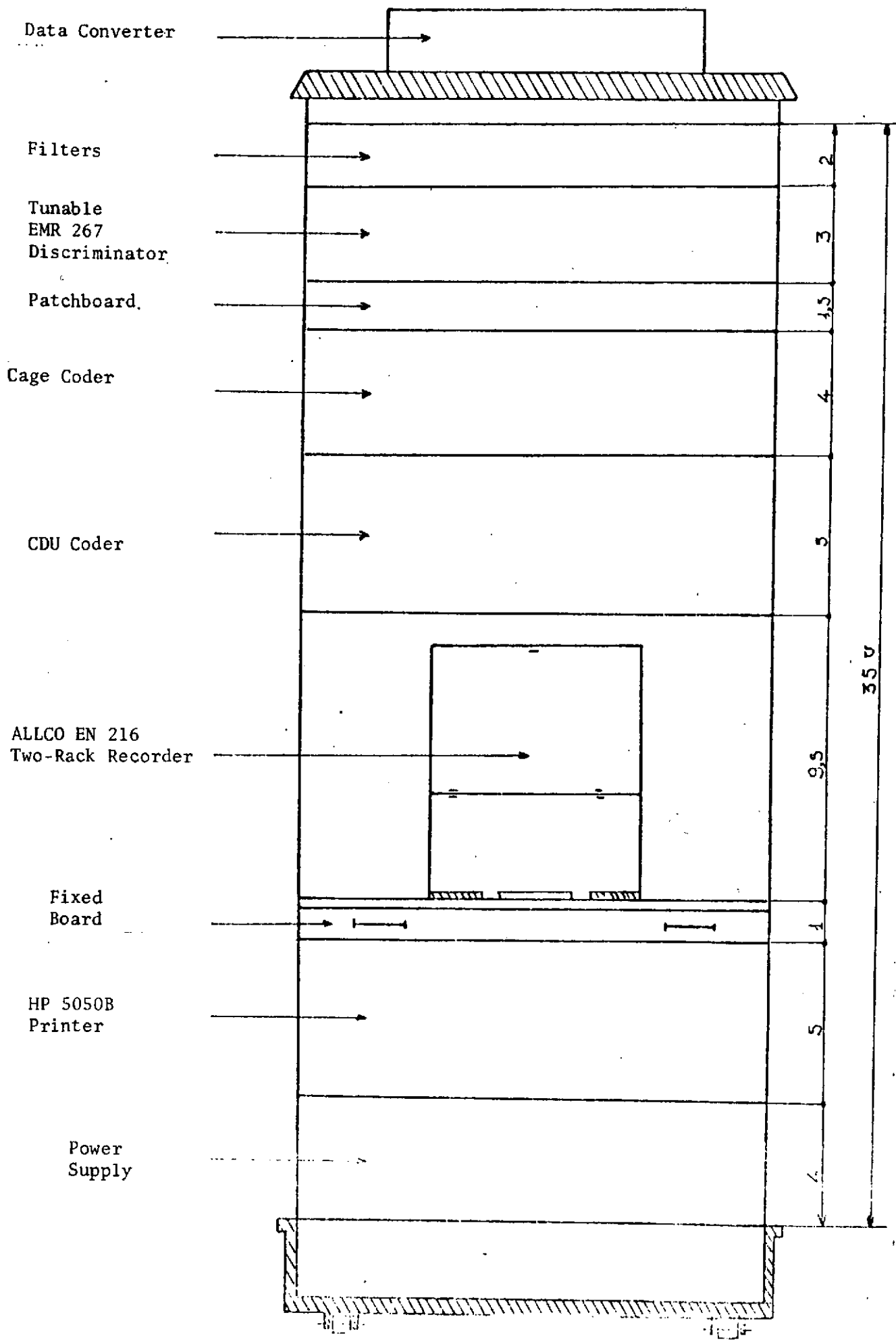
/17

Since the PCM decommutation function is localized in the secondary ITTC synchronizer, all that remained was to make up one rack containing the PAM and command guidance decommutation functions. This rack was placed, during operations, in the immediate vicinity of the secondary ITTC synchro.

This SMS exploitation rack is a mobile 35U Thomson rack. It is fitted with all the necessary slide bars as well as two power outlet boxes with 6 electrical sockets (1 220 V box and 1 110 V box). In addition, it includes:

- 1 switchboard for the purpose of ensuring communications between the specific SMS equipments and the patchboard of the BZV station;
- 1 stationary plate for the purpose of supporting an ALLCO EN 216 recorder;
- 1 fixed board.

The physical placement of the equipments in the SMS operations rack is as follows:



#### 4.2.4. Installation of Interconnecting Cables

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A great many different types of interconnecting cables have been installed at the Toulouse station. Their listing is not important. However, the principle governing this installation was as follows:

- All the specific cables will be installed by the Toulouse station (or supplied by NASA).
- The BZV station will only have to supply basic coaxial communication.

The specific cables were shipped to BZV at the same time as the material. The listing of the cables to be supplied by the BZV station was specified in the memorandum 9410/73/024 of 7 November.

#### 4.3. Study of Interface Problems

##### 4.3.1. Functional Flow Chart of Equipments Utilized

The functional flow chart is given on the following page.

The interface problems to be solved naturally become clear from this flow chart: /21

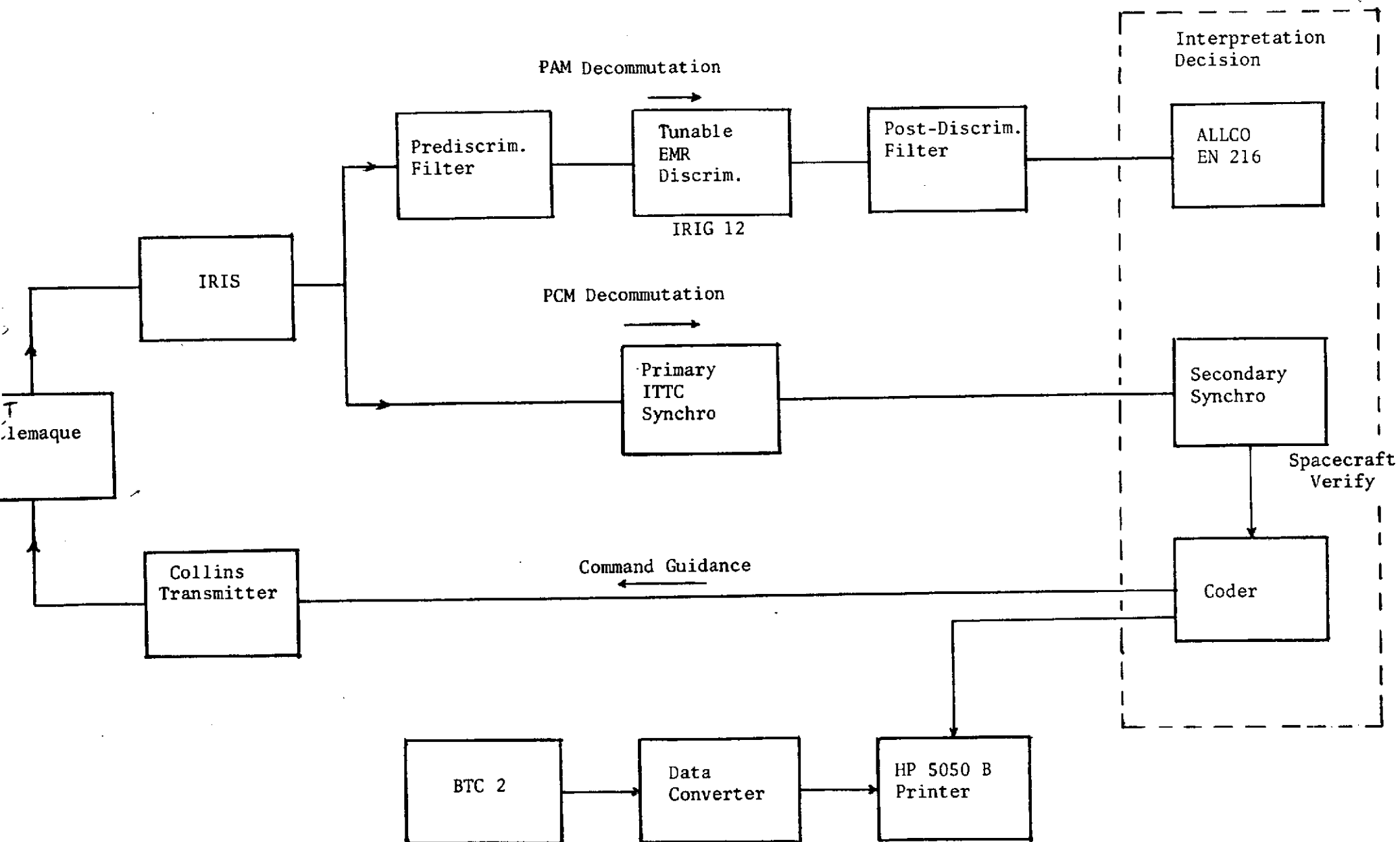
- Collins transmitter - Télémaque antenna interface.
- Command guidance coder - PCM decommutation interface.
- Printer - Station time interface.

##### 4.3.2. Collins Transmitter - Télémaque Antenna Interface

This interface is in reality merely made up by a cable which was installed at the station. It concerns a coaxial K×4, 12 meters long, fitted with one straight RADIAL type N plug (transmitter side) and one straight RADIAL type N socket (antenna side). The transmitter-antenna connection will be accomplished in the local station transmitter.

##### 4.3.3. Command Guidance Coder - PCM Decommuration Interface

The word 4 (bits 2 to 9) of the SMS telemetry gives the content of the "command guidance" memory of the satellite. This word can be inputted to the ground coder. This coder then compares the order which it has itself transmitted with the content of the embarked memory. This comparison is called "Spacecraft Verify". In case of absence of "Spacecraft Verify" there is a warning signal at the coder.



FLOW CHART OF SMS OPERATIONS AT BZV

Although this warning signal can be bypassed, it appeared advantageous for us to profit from this capability offered by the equipment, whence the requirement for installing the ITTC, command guidance coder interface equipment.

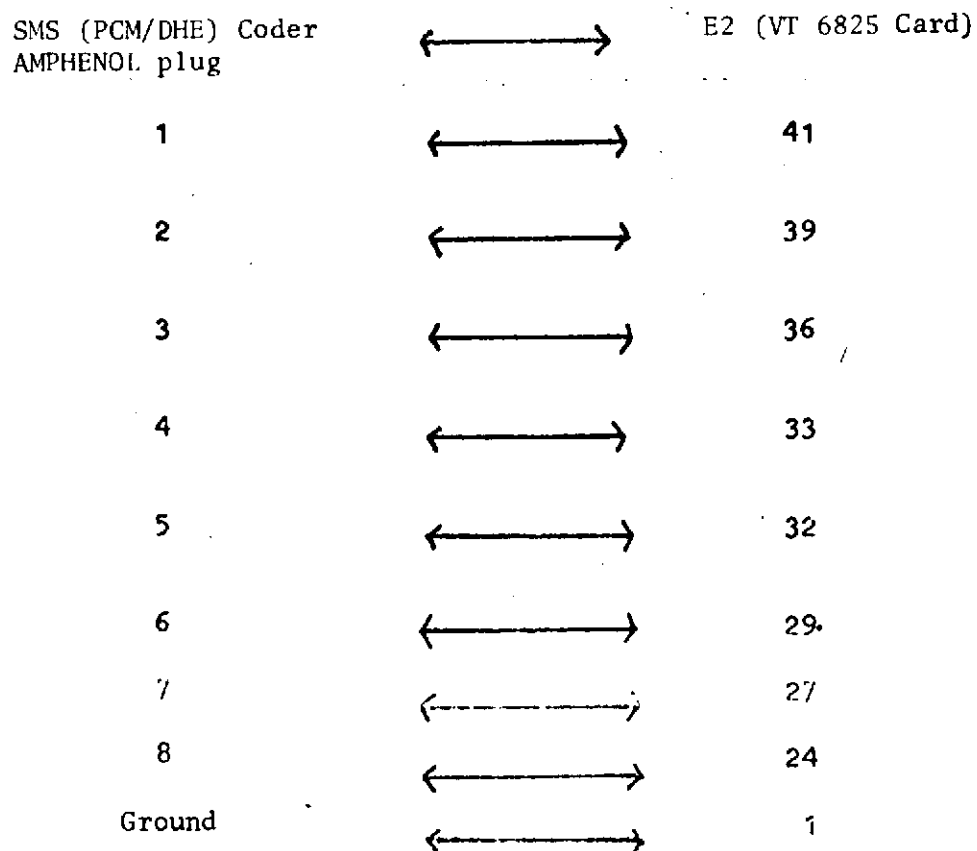
The solution used is as follows:

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The word 4 (bits 2 to 9) is addressed on the manual display No. 1 of our secondary synchro. The data is then used bit by bit and input on the PCM/DHE plug of the coder, the clock being taken beginning from 128 Hz available on the coder panel (CAGE drawer unit).

With the secondary synchro, the data is taken directly on the "pins" available at the base of the connector of the AVD E2 card of the VT 6825 drawer unit.

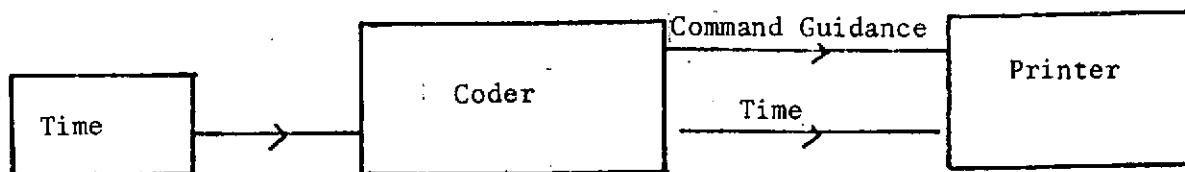
One cable was, for this reason, installed with a male AMPHENOL plug at one end and adapted to the PCM/DHE plug of the coder. At the other end, 9 female terminals were installed directly on the connector of the card. The connection system of this cable is as follows:



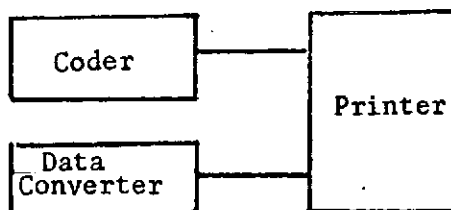
The operation of this link has been tested using the PCM simulator and gives complete satisfaction.

#### 4.3.4. Printer - Station Time Interface

The standard assembly specified by NASA is as follows:



Since NASA only supplied us with a single cable out of the three required for this assembly, it appeared simpler to install the following assembly:



The two problems to be settled were then as follows:

- Manufacture a data converter - printer cable. Since the coding of the data converter output is different from that of the printer input plug, it appeared appropriate to use a Hewlett Packard 50 conducting cable fitted with two AMPHENOL plugs and to modify the cable from one of the two plugs.

- Connect a 5V circuit breaker to the time tap-in of the printer. Since this 5V is already supplied by the coder to the data input from the printer, we set up a bridge in the printer between pins 24 and pins 25 of the two input tap-ins.

Operation completely satisfactory.

## 5. SIMULATION OF SMS TELEMETRY RECEPTION

### 5.1. Goal

The goal of simulating reception of SMS telemetry was as follows:

- development of PCM decommutation;
- development of discrimination of the IRIG 12 channel, carrier of the nutation data, and study of display of this data with analog recorder.

The source of this simulation was made up by a magnetic tape recorded at NASA and representative of SMS telemetry.

### 5.2. PCM Decommutation

The development of PCM decommutation gave no difficulty.

The format of the programming card of the PCM rack is provided on the following page.

The selection of displayed parameters was done as follows:

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- Six channel display
  - channel 1 : TM 1 or 2 ON
  - channel 2 : VHF transmitter 1 or 2 ON
  - channel 3 : transmitter power LOW or HIGH
  - channel 4 : "Execute Verify" data
  - channel 5 : ADAC 1 or 2 ON
  - channel 6 : position of the ENABLE/DISABLE relay
- Two-channel display (manual)
  - channel 1 : "Spacecraft Verify" (see paragraph 4.3.3.)
  - channel 2 : ANC ON/OFF
  - ANC NORMAL/RESCUE

The system of these displays is representative of the embarked configuration of the embarked automatic nutation monitoring system of the satellite.

Taking its importance into account, this display program will form the subject of a discussion on the occasion of our next meetings with the Action Officers of the Project group.

# STATION PCM PROGRAM

Prog. short cycle synchro code Message BPSP

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32

masks

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32

synchro code length syn. mode position of the ID word Length ID word ID word ID error windows

word length short cycle length long cycle length

S1 syllable length S2 syllable length S3 syllable length S4 syllable length computer syllable

rhythm

1st figure 2nd figure 3rd figure exponent

BP Codes Pol. Cal. band outside detect source noise

range

SECOND SY

TRAN. PRIM.  
FORM. SY

(Proposa1)

SKS-A

STATION PCM PROGRAM

STATION:

BZY

PHASE:

Launch

DISPLAY

Channel 1 2 3 4 5 6 7 8 9 10 11 12

8 first bits  
8 last bits  
BPS BMS

syllable

words

short cycles

type  
0 super com  
1 normal  
2 super below com  
3 below com

period

### 5.3. Display of the Satellite Nutation Movement

#### 5.3.1. Waveform of the Nutation Signal

At the output of the accelerometric sensor measuring the satellite nutation movement, an alternating voltage with variable amplitude is collected /27  
as follows:

- The frequency of this signal provides us with the nutation frequency which is directly connected to the spin frequency of the satellite:

$$F \text{ nutation} = \left(1 - \frac{I_z}{I_x}\right) F \text{ spin}$$

This nutation frequency is normally a very low one, on the order of 1 Hertz.

- The amplitude of this signal provides us with the satellite nutation angle.

This alternating voltage drives a VCO turned on the IRIG 12 channel ( $F_0 = 10.5 \text{ kHz}$ ), then the telemetry system of the satellite.

The nutation angle - frequency deviation correspondance at the VCO output is given here for information:

Nutation Angle (°)	$\Delta F$ (Hz)	Nutation Angle (°)	$\Delta F$ (Hz)
0.18	1	3	20.2
0.35	2	4	22
0.5	3.5	5	24
1	6.75	7	27.8
1.5	10	10	33
2	13.5		

(Extracted from document SMS-PCC-5685 of 18 March 1973).

It is important to note that, for the nutation angles in which we are /28  
interested, less than 1 degree, the frequency excursion is very low, representing less than 1% of the maximum excursion of the VCO.

### 5.3.2. Readout of the Magnetic Tape Supplied by NASA

The video recorded on the magnetic tape supplied by NASA has been reread using the tunable discriminator of the station adjusted to the IRIG 12 channel. Only noise was collected as output from the discriminator.

The readout of the track carrying the reference frequency (10 kHz) has given the same result as output from the discriminator, tuned this time on this reference frequency. It should therefore be assumed that the telemetry carried neither nutation data nor APS pulses.

It should be noted that even assuming that there was a datum corresponding to a low nutation angle -  $0.35^\circ$  for example - the latter could not have been exploited easily. Indeed, this nutation angle corresponds to an  $\Delta F$  of 2 Hz or 0.2% of the recorded central frequency.

### 5.3.3. Simulation Starting from a Station Model

Since readout of the magnetic tape did not provide any result, a series of experiments was carried out using an assembly developed at the station. One VCO IRIG 12 was driven by a very low frequency generator whose output level was modified using an attenuator. The VCO output was mixed with the SMS PCM train taken on NASA magnetic tape. The mixture of the two signals drove the receiving and decommutating chains. The testing configuration is shown on the two following pages.

5 ALLCO recordings were made in this way:

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No. 1 : energizing the discriminator by the output from the VCO alone.

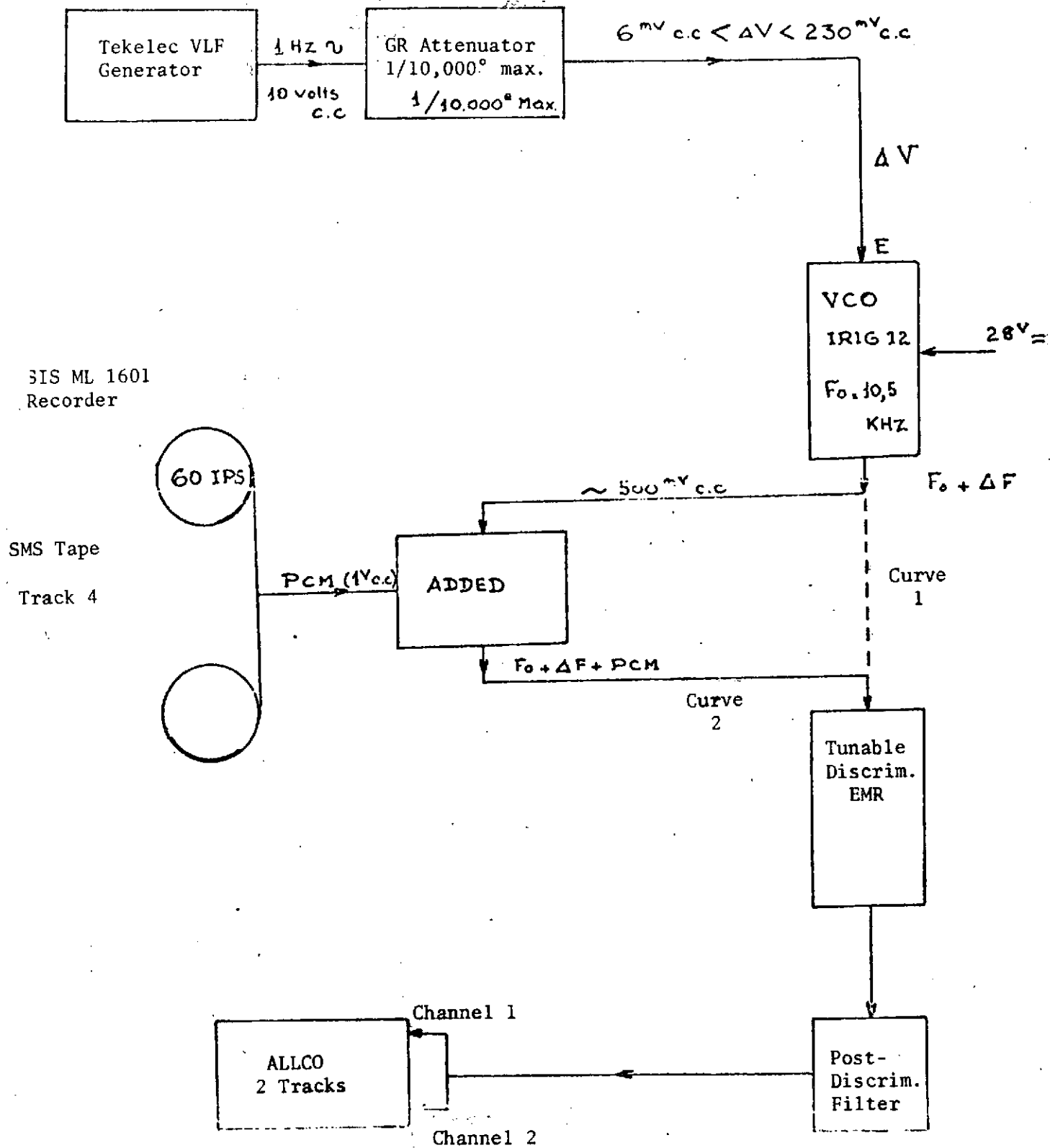
No. 2 : energizing the discriminator by the output from the VCO mixed with the PCM.

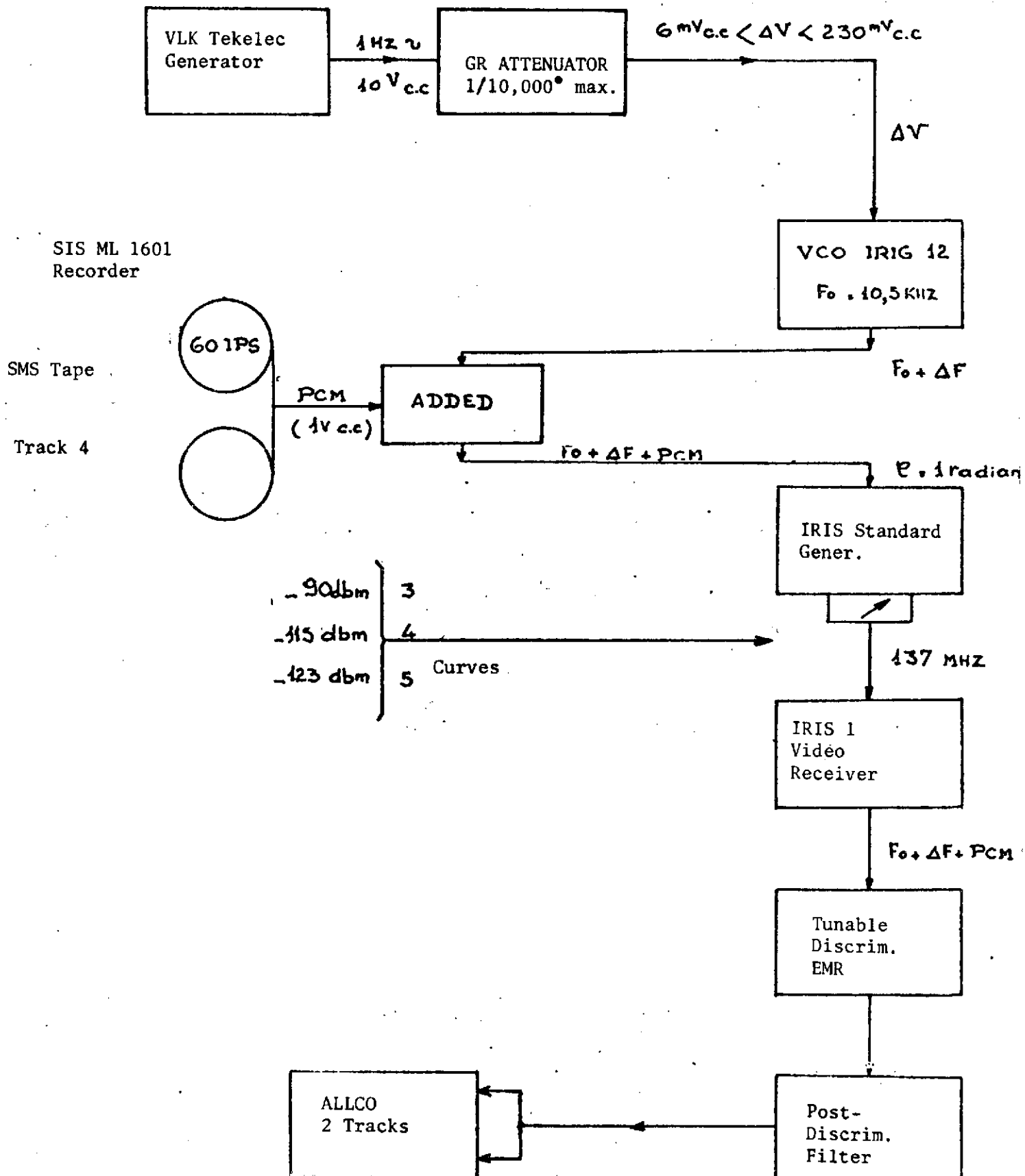
Nos. 3, 4 and 5 : energizing of the discriminator through the output from an IRIS receiver for three levels displayed at the calibration generator : -90, -115 and -123 dBm.

These recordings are appended to the present report.

They have turned out to be perfectly exploitable, even with a weak receiving field.

# CONFIGURATION OF TESTS 1 AND 2





Note that this simulation is in no way operational, calling upon borrowed material whose employment is difficult. It only tended to demonstrate the feasibility of the operation, at the same time using a source of local conception which is not necessarily representative of the telemetry transmitted by the satellite. It appears too that it is up to NASA to "adjudge" this simulation.

## 6. COMMENTS

The comments and reservations stemming from the tests conducted in collaboration with J. C. Anne at the Toulouse station are the following:

### 6.1. Command Guidance Link

No reservations. The only problems to be feared are, as usual, breakdowns becoming a factor in the last instants of timekeeping since the equipments used are not redundant.

### 6.2. PCM Decommutation Link

No reservations. The opinion of NASA can only be requested concerning the opportunity for displays which we plan to program.

### 6.3. Discrimination Link of the IRIG 12 Channel

The following points remain to decide:

- prediscriminator filter : terminate production, tests to conduct.
- post-discriminator filter : study of its behavior in presence of APS pulses.
- tunable discriminator : study of its behavior in presence of APS pulses.

### 6.4. Simulation at BZV Before Transit

This point has so far not been cleared up. It is up to NASA:

- to state the feasibility of the operation in the light of tests carried out at Toulouse;
- to supply a "source" representative of the IRIG 12 channel allowing the following to be carried out at BZV:

- a complete simulation;
- a calibration of the analog recorder without which it will not be possible to measure the nutation angle of the satellite.

## 7. CONCLUSION

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The technical aspect of the SMS operation, subject of this series of experiments, has been studied in detail.

The difficulties encountered, as well as the points to be cleared up have been transmitted to NASA (copy of the telex attached as annex).

A meeting with the Action Officers of the Project group is presently programmed at GSFC from 7 to 11 January 1974.

It will be used to advantage to settle the last technical problems still pending.

CHIEF OF STATION

[signed]

M. KUDLIKOWSKI

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